

Strategic Conservation Planning in Maine's Bagaduce River Watershed

*Prepared for the Maine Coast Heritage Trust and the Blue Hill Heritage Trust*

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## **Abstract**

Maine's Bagaduce River watershed is considered an area of statewide ecological significance. It provides important breeding, foraging, and migratory habitat for a number of species and features thousands of acres of wetlands. Two active land trusts in Maine—the Maine Coast Heritage Trust and the Blue Hill Heritage Trust—are partnering to protect land in this biodiverse region and sought to develop a new and more strategic conservation plan for the watershed.

Since funds and resources for conservation are typically limited, it is important to go through a strategic planning process to identify land parcels which offer the highest conservation benefit. Strategic conservation planning is critical because it helps guide the best use of funds and can identify key landowners for outreach efforts. This prioritization process requires the development of a decision framework to formalize and guide decision making. Combining this framework, in the form of a written plan, with geospatial analyses is useful since it reveals the distribution of conservation features across the landscape that are of highest concern to the land trust.

For this master's project, a strategic conservation plan was created to guide conservation efforts in the Bagaduce River watershed. The ecological component of the plan is presented for the scope of this project. First a decision framework was established in the form of an objectives hierarchy. For each objective, a measurable indicator was determined to provide a concrete means of measuring conservation progress. Each of these indicators was analyzed geospatially both separately and with other indicators in order to identify areas of highest ecological value in the watershed. Moving forward, this plan is meant to serve as an additional decision support tool for MCHT and BHHT when selecting and evaluating potential land projects in the region.

## **Acknowledgements**

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## **Introduction**

It is no secret that funding and resources for land conservation are limited. This suggests the need for strategic conservation planning to help land trusts recognize and identify land projects that maximize conservation benefit. Pairing written plans with geospatial analyses is useful for land trusts because it helps reveal the distribution of resources across the landscape. Furthermore, strategic planning at the parcel level helps identify key stakeholders with whom the land trust should begin establishing a relationship (Amundsen 2011). Land protection does not happen overnight and cultivating relationships with landowners can sometimes takes years or even decades. Planning and prioritizing is also beneficial because it demonstrates to donors, foundations, grant programs, and members of the organization that the land trust has an overarching agenda and that money and resources are being used efficiently and strategically (Amundsen 2011). Lastly, having a strategic conservation plan can help ensure that land trusts accept land or initiate projects that are consistent with their mission and avoid wasting time on land projects with limited conservation potential (Land Trust Alliance 2004).

Two land trusts in Maine, the Maine Coast Heritage Trust (MCHT) and the Blue Hill Heritage Trust (BHHT), are currently partnering to protect land and resources in the Bagaduce River watershed, a region identified by the state of high ecological significance (Beginning With Habitat 2003). For my master's project I developed a strategic conservation plan to aid these two land trusts in selecting and prioritizing land projects in the region. In addition to creating a written plan, I used a geospatial approach that resulted in a series of maps to further guide the decision making process. For the scope of my master's project, I focused on highlighting areas of highest ecological value.

## *Background on Strategic Conservation Planning*

Strategic conservation planning is centered around the idea that a land trust should engage in a decision making process that supports its fundamental mission (Amundsen 2011). This idea is nationally recognized among the land trust community in the guidelines described in the Land Trust Alliance's *Land Trust Standards and Practices*: Standard 1 (B) recommends that "the land trust regularly establishes strategic goals for implementing its mission and routinely evaluates programs, goals and activities to be sure they are consistent with the mission" (Land Trust Alliance 2004, p. 1). Standard 8 also (B) advocates that "The land trust carefully evaluates and selects its conservation projects" (Land Trust Alliance 2004, p. 8).

In order to prioritize areas for conservation, land trusts need to have a decision framework. This calls upon the discipline of structured decision making. Gregory et al. (2012) define structured decision making as "the collaborative and facilitated application of multiple objective decision making and group deliberation methods to environmental management and public policy problems" (p. 6). The prioritization of land conservation projects relies on a structured decision framework in order to establish a series of nested conservation objectives that are collectively known as an objectives hierarchy. An objectives hierarchy consists of general objectives and specific sub-objectives that further break down those objectives (Gregory et al. 2012). These objectives or sub-objectives define the project selection criteria land trusts use when evaluating land parcels. In other words, project selection criteria and sub-objectives describe the desired characteristics a property should have in order to be attractive to the land trust. For each sub-objective, land trusts should ideally have measureable indicators that provide a way of evaluating progress and provide clarity about what is meant by each of the objectives

(Gregory et al. 2012; The Nature Conservancy 2011; The Nature Conservancy 2003). For instance, a general objective could be to conserve lands of high quality habitat. One of the sub-objectives for this objective could be to focus on lands that enhance ecological connectivity. The measureable indicator for this sub-objective (or project selection criterion) might be the distance of a parcel to an existing protected area, or whether or not a parcel is adjacent to a protected area. Not all organizations have direct or measureable indicators for each of their land project selection criteria, but having indicators is necessary in order to conduct a geospatial analysis and to help provide a measure of success.

There is considerable variability across land trusts in how formal the decision making process is for selecting new land projects. One approach for evaluating the merit of a land project is qualitative and usually entails land trust staff and board members reviewing and checking off of a list of desirable (or undesirable) property conditions on a project by project basis (Amundsen 2011). Some land trusts have broad selection criteria, while others have more narrowly-defined targets. For example, three of the 14 criteria that the Peconic Land Trust (Southampton, NY) uses to evaluate its projects for public conservation benefit are as follows: “The property includes important wildlife habitats and/or known migration routes,” “The property is in active agricultural use,” and “The property shares a common boundary with publicly preserved land or other significant open space areas” (Peconic Land Trust 2013). The Peconic Land Trust also lists several criteria that would make the organization disinclined to accept or initiate a land project. Examples include “The conservation value of the property is likely to be significantly diminished by the development of adjacent property” and “The landowner insists on conditions that the Trust believes will seriously compromise the conservation value of the property” (Peconic Land Trust 2013). Other examples of undesirable



criteria are described by the Monadnock Conservancy in Keene, NH: the Conservancy generally avoids projects that “Pose actual or potential hazards from man-made substances or structures,” or “Are insufficient in size to protect the conservation values at stake,” among others (Monadnock Conservancy 2007). This qualitative approach still relies on having clear conservation objectives but does not necessitate spending time and resources on a more quantitative, computer-based approach, which can be costly and relies on data being available. This approach varies in its degree of formality, based on how structured of a decision framework the land trust has in place.

Another approach is to set minimum thresholds for certain property characteristics that must exist in order for the project to move forward (Amundsen 2011). An example of this approach would be if a coastal organization decides to only select parcels with a minimum number of feet of short frontage. Another threshold condition would be a *requirement* of adjacency to an existing protected area.

Making use of a scoring system is a third method used for evaluating land conservation projects (Amundsen 2011; The Nature Conservancy 2003). Under this approach, a certain number of points is allocated for each criteria that has been satisfied by a given project. Scoring requires that the land trust determine how important each sub-objective (or selection criteria) is. For example, a land trust could score parcels based on size, where a parcel with an acreage of 0-25 acres gets a score of 0.25, a parcel with 25-50 acres gets a score of 0.50, a parcel with 50-75 gets a score of 0.75, and a parcel with 75 or more acres get a score of 1. The scoring system is up to the land trust and many different scoring schemes exist. This approach is attractive because it makes decisions quantitatively based once the scoring framework has been determined.

However, determining appropriate scores can be challenging and somewhat objective (Amundsen 2011).

Land trusts using a quantitative, score-based approach sometimes weight certain criteria more heavily than others (Gregory et al. 2012; Amundsen 2011; The Nature Conservancy 2003). Decision makers use a variety of approaches to determine the actual procedures for weighting (Amundsen 2011). A land trust might decide to use this approach if it has a broad mission statement and has developed several different objectives for a plan, but finds some more important than others. For instance, a land trust might decide to put more emphasis on public recreation benefits, than preserving prime agricultural soils, even though it is interested in both recreation and agriculture.

Quantitative approaches to prioritization can be carried out in a geospatial context, if the appropriate data is available. Doing so reveals which parcels receive the highest score, and thus are top priority for protection (Amundsen 2011). However, the disadvantage of scored parcels is that the decision maker has no way of knowing how each parcel scored for each criterion by looking at the final map alone. Arguably, the user loses some information by relying on aggregated scores. While the information is not all included on a printed, physical map, this could be remedied with technology by examining the geographic information system (GIS) attribute table for the parcel, or by generating an extensive spreadsheet with information for every parcel in the region. However, this lacks practicality for land trust staff that lack GIS knowledge or want a quick visual representation of how resources of conservation value are distributed over the landscape. Furthermore, this system, as with most geospatial analyses, requires considerable upkeep since data is always changing.

Rather than using a quantitative geospatial approach, some land trusts use GIS to guide decision making by conducting an overlay analysis. This often consists of mapping a set of data layers (of different natural resources, for example) one by one, and then including multiple data layers on the same map (Amundsen 2011), each with a unique symbology. Overlay analyses are particularly useful because they allow the decision maker to see the distribution of resources across the landscape and determine which project selection criteria have been met in which areas. This differs from the score-based approach, which assigns parcels a numeric score without necessarily revealing *which* criteria have been satisfied. Thus, more specific information is provided than if one were to use a score-based system alone. This GIS approach is less subjective upfront in that no decision has to be made ahead of time about the relative importance of each of the selection criterion.

In most cases, decisions are also iterative, meaning that the best selection depends on the previous decision. Thus, maps constantly need to be updated. Using a software program like PORTFOLIO (Urban 2002) is particularly useful when decisions are iterative, as it incorporates new information and reveals the optimal and more efficient choice, based on the previous selection (Urban 2002). While PORTFOLIO can help identify the best parcels for protection (given the data provided), it is not a geospatial program and thus does solve the conundrum of having outdated maps.

Many land trusts use a combination of these approaches when considering and evaluating the potential of a given conservation project. Regardless of whether a land trust uses a qualitative or quantitative approach, or a combination, the decision to go through with a project is ultimately at the discretion of land trust staff and/or board members. There may be additional

factors that cannot be captured by the geospatial analysis or that are not explicitly described in the land trust's project selection criteria that merit consideration.

The level of stakeholder involvement in strategic decision making and the conservation planning process varies depending on the purpose of the plan (Gregory et al. 2012; Amundsen 2011). Some land trusts, especially those that are more community-based in nature, actively seek input from both their members and the communities they serve as part of this process. However, Amundsen (2011) describes that public involvement is not always appropriate: "If... one of the plan's goals is to serve as an internal tool to identification the location of sensitive resources, such as rare orchids or archaeological sites, then the role of the public may be more limited" (p. 65).

The scope of a strategic conservation plan varies considerably, depending on the size of the land trust, its service area, and the scale of its activities (Gregory et al. 2012; Amundsen 2011; The Nature Conservancy 2003). As with any plan or decision framework, there may be nested levels of decisions that must be made and context-specific objectives (Gregory et al. 2012). Is the strategic conservation plan aimed at the land trust's entire service area, or a sub-region or focus area within the trust's service area? A land trust may have an overarching conservation plan, with individual plans for each of its focus areas or other regions of particular interest.

### *Objective of Master's Project*

My objective for my master's project was to create a strategic conservation plan with a series of accompanying maps that would help MCHT and BHHT prioritize land parcels for

conservation in the Bagaduce River watershed in Maine. The product is meant to be a practical, stand-alone, printed plan to guide decision making that does not rely on either land trust actively using GIS or other technology, unless they choose to do so.

### *Background on Maine Coast Heritage Trust and Blue Hill Heritage Trust*

MCHT and BHHT are both land trusts that conserve land in Maine by acquiring it through purchase or donation, or by establishing conservation easements on private property. In addition to their land protection efforts, both land trusts are engaged in community outreach efforts in their respective service areas.

The mission of the Blue Hill Heritage Trust is “To conserve land and water of special ecological, natural, agricultural, scenic, cultural and recreational significance in Blue Hill, Brooklin, Brooksville, Penobscot, Sedgwick and Surry and to increase public understanding of the importance of land and water conservation” (BHHT 2013). The Trust has protected approximately 6,600 acres on the Blue Hill peninsula (BHHT 2013).

MCHT is a state-wide land trust which works both on its own and by partnering with local organizations to conserve land along Maine’s coastline. The mission statement of the Maine Coast Heritage Trust: “Maine Coast Heritage Trust (MCHT) conserves and stewards Maine’s coastal lands and islands for their renowned scenic beauty, ecological value, outdoor recreational opportunities, and contribution to community well-being. MCHT provides statewide conservation leadership through its work with land trusts, coastal communities and other partners” (MCHT 2013). MCHT has conserved over 138,000 acres in Maine, including over 300 coastal islands (MCHT 2013).

### *Project Study Area*

The project area covers an area of 316.44 square kilometers and encompasses the Bagaduce River and its watershed (Figures 1 and 2). The river is approximately 12 miles long and originates near the town of Penobscot, Maine and empties into Penobscot Bay (Beginning With Habitat n.d.). The river and its surroundings have been identified by the state's Beginning With Habitat program as a statewide ecological focus area because of the "unusually rich concentrations of at-risk species and habitats" (Beginning With Habitat n.d.). Specifically, the watershed provides habitat for migratory and breeding birds, including both waterfowl and shorebirds, is one of only a few sites in Maine where horseshoe crabs breed, provides breeding grounds for diadromous fish, has known nesting locations for bald eagle—a species of special concern in the state of Maine (Beginning With Habitat n.d.), and contains several wetland types of federal priority (National Wetlands Inventory geospatial data 2011; USFWS BHC 2014). The Bagaduce River watershed also provides extensive opportunities for public recreation, both on land and on water, and contains several areas of statewide scenic significance (DeWan and Naetzker 1990). Lastly, it supports habitat for marine worms and a variety of mollusks. The harvest of these species is a significant economic industry in the region.

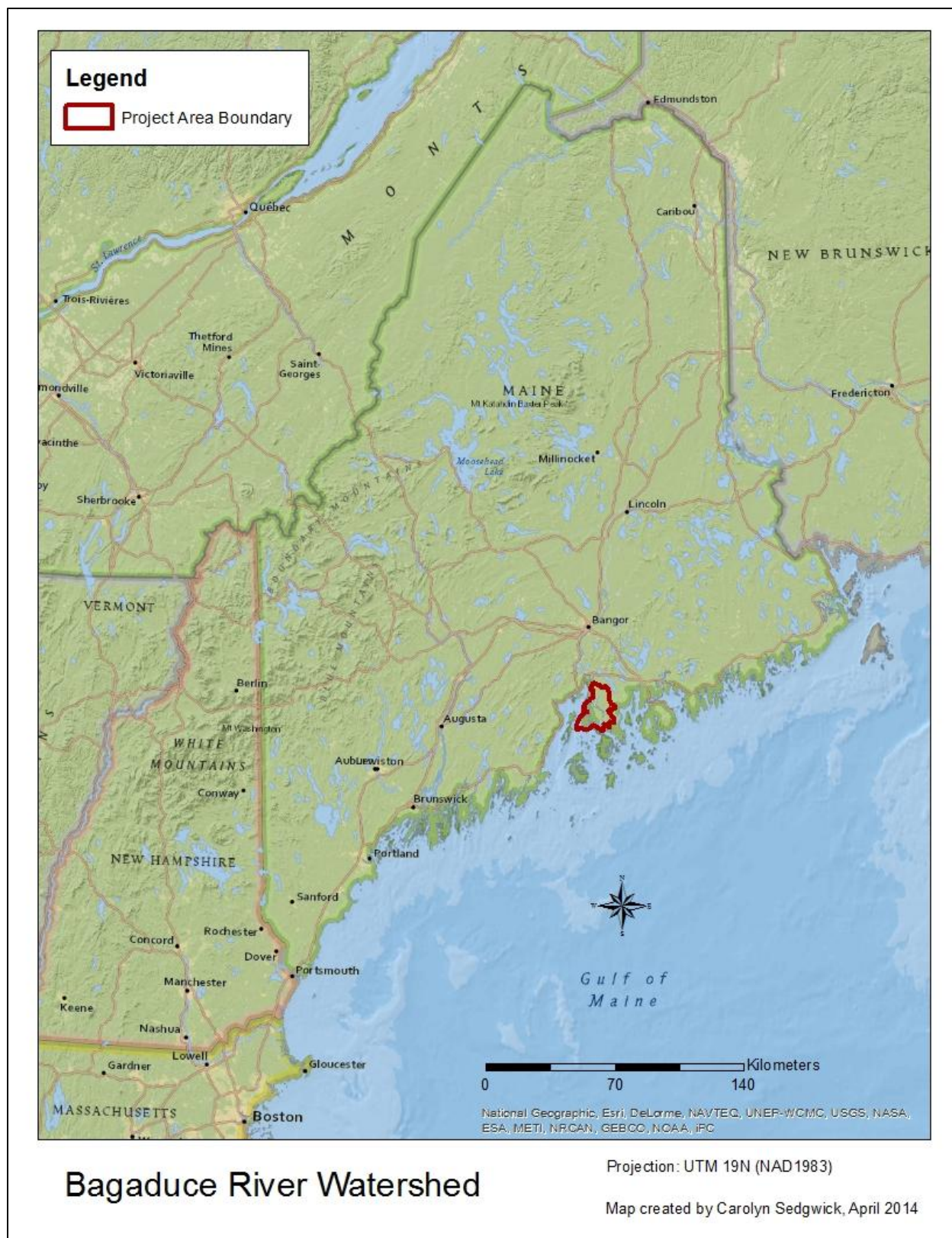


Figure 1. Coarse-scale Map of Bagaduce River Watershed







## Methods

The methods of my master's project were twofold: first I worked with MCHT and BHHT to establish a decision framework for this strategic conservation plan. Subsequently, I acquired the appropriate data and performed a series of geospatial analyses that resulted in a set of maps.

### *Decision Framework*

While both MCHT and BHHT have overarching project selection criteria that they use to evaluate all conservation projects for their respective land trusts, the two organizations designed a set of objectives unique to this watershed-specific plan.

First Ciona Ulbrich, Senior Project Manager at MCHT, and Jim Dow, Executive Director at BHHT, established the purpose of the Bagaduce River watershed strategic conservation plan. Together we then created an objectives hierarchy which consisted of ecological objectives that were consistent with the mission statements of both land trusts. Each sub-objective had a measurable indicator for which relevant geospatial data was available. For this particular conservation plan, planning decisions were made internally.

Plan Purpose: To help guide future land conservation efforts in the Bagaduce watershed by identifying areas within the watershed that are worthy of conservation because of their high ecological, recreational or scenic values, the conservation of which will afford long-term benefits to humans and wildlife.

### Plan Objectives:

1. To identify and map the wetlands, water bodies and shoreline stretches within the watershed that are of highest importance to wildlife
2. To identify and prioritize parcels of land that warrant conservation because of their ecological value, including both wetlands and uplands
3. To identify and prioritize parcels of land that warrant conservation because of their potential for low impact recreational use, including public access points
4. To identify and prioritize parcels of land that warrant conservation because of their value as scenic resources

While the scenic and recreational objectives are both of high importance to BHHT and MCHT, for the scope of my master's work I focused only on the ecological component of this strategic conservation plan. Despite the exclusion of scenic and recreational objectives from the geospatial component of this plan, they could be included at a later point, if appropriate and measurable indicators were determined.

The sub-objectives we determined for these ecological indicators included maximizing ecological connectivity, protecting habitat for endangered, threatened, or declining species, protecting eelgrass beds, focusing on wetlands of “federal priority” (as determined by North American Wetlands Conservation Act grant scoring: USFWS BHC 2014, p. 16), and focusing on large parcels. Measureable and representative indicators for these sub-objectives were decided collaboratively. Five non-redundant indicators were chosen and incorporated into the geospatial analysis: adjacency to existing conserved land, wetland status (federally prioritized or all other wetlands) and size, parcel size, eelgrass habitat presence, and habitat suitability (Table 1). Geospatial data existed for all five of these indicators (Table 2). The habitat suitability data was derived from the Gulf of Maine Watershed Habitat Analysis data (USFWS GMCP 2013) for

which habitat quality for 91 species of particular concern was assessed (see Table 2 for description and Appendix A for full species list).

Indicator	Measure
Adjacency to existing conserved land	Distance
Wetland habitat	Wetland type and size
Parcel size	Acreage
Eelgrass habitat	Presence/Absence
Habitat suitability	Gulf of Maine Watershed Habitat Analysis aggregated species scores

Table 1. Ecological Indicators

### *Geospatial Data*

Data	Description	Date	Source	Format
Bagaduce Project Area Boundary	Polygon showing the extent of the project area in the Bagaduce River watershed	2011	Maine Coast Heritage Trust	Vector
Conserved Lands	Existing federal, state, municipal and non-profit protected areas. Owned or in easement	3/25/2014	Maine Office of GIS	Vector
Gulf of Maine Watershed Habitat Analysis--aggregated species scores	Prioritized habitat for 91 species that fall into at least one of these categories: federally endangered or threatened; migratory birds and diadromous or estuarine fish that are declining nationwide; migratory birds and diadromous or estuarine fish that have been identified as endangered or threatened by at least two states in the Gulf of Maine watershed	3/2001	USFWS Gulf of Maine Coastal Program	Raster
National Wetlands Inventory	Location and types of wetlands	9/26/2011	USFWS; Maine Office of GIS	Vector
Eelgrass beds	Location of eelgrass beds as of 2010	5/24/2012	Maine Department of Marine Resources	Vector
Town of Blue Hill Tax Parcels	Tax parcel boundaries for Blue Hill, Maine	1/28/2014	Maine Office of GIS	Vector
Town of Brooksville Tax Parcels	Tax parcel boundaries for Brooksville, Maine	1/28/2014	Maine Office of GIS	Vector
Town of Castine Tax Parcels	Tax parcel boundaries for Castine, Maine	1/28/2014	Maine Office of GIS	Vector
Town of Orland Tax Parcels	Tax parcel boundaries for Orland, Maine	1/28/2014	Maine Office of GIS	Vector
Town of Penobscot Tax Parcels	Tax parcel boundaries for Penobscot, Maine	1/28/2014	Maine Office of GIS	Vector
Town of Sedgwick Tax Parcels	Tax parcel boundaries for Sedgwick, Maine	1/28/2014	Maine Office of GIS	Vector

Table 2. Geospatial Data Sources

## *Data Preparation*

Before I conducted my analyses, I made preliminary changes to the majority of the datasets used in this analysis. The only data that was not altered in some way was the Bagaduce Watershed Project Area Boundary, which was provided to me by MCHT. For all geospatial analyses, I used ArcGIS version 10.2 (ERSI, Redlands, CA)

### Wetland Dataset

I clipped the National Wetlands Inventory (NWI) dataset to the watershed boundary, which resulted in 1,500 wetland polygons within the study area. These 1,500 wetlands areas fell into 112 different wetland classification types consisting of a series of letters and/or numbers (USFWS 2011). Cowardin et al. (1979) describe what each of these codes means ecologically.

I pooled and coded the wetlands data based on the national status of the wetland type, as defined in the North American Wetlands Conservation Act (NAWCA) standard grant scoring protocol (USFWS BHC 2014, p. 16). Wetland types that are classified as decreasing or stable are given priority for conservation under the NAWCA grant program (USFWS BHC 2014). Wetland types considered to be either stable or decreasing in the United States were pooled as “Federal Priority Wetlands” and all wetlands that are considered of an increasing type or a type for which no trend data exists were pooled as “All Other Wetlands.”

### Tax Parcel Datasets

I merged the town tax parcel datasets for each of the six towns that the Bagaduce River watershed encompasses. I then clipped the resulting dataset to the watershed boundary so that I was left with only the parcels within the project area. Subsequently, I added a field to the attribute table and calculated the acreage of each parcel.

### Eelgrass Habitat, Conserved Lands, and Gulf of Maine Watershed Habitat Analysis Datasets

These three datasets were each manipulated to have the same spatial extent as the Bagaduce River watershed.

### *Geospatial Analyses*

Each of the five ecological indicators was first mapped separately on its own map. In order to map the adjacency indicator, I created a dataset containing only parcels adjacent to existing preserves or conservation easements. I did this by selecting parcels that were within 10 meters of existing conserved land (Appendix B). I then created a new data layer consisting only of parcels adjacent to conserved parcels.

After mapping each of the indicators individually, I conducted a series of overlay analyses for which I mapped multiple indicators on the same map. This highlighted the areas of highest ecological importance (Amundsen 2011). Ultimately I chose not to include maps with more than three indicators featured at once because they were too complicated and crowded to actually be useful or interpretable.

## Results

Each of the maps produced from my geospatial analyses are meant to help highlight areas of high ecological importance. Figures 3-7 each reveal the spatial distribution of one of the five ecological indicators individually. Figure 3 reveals all the parcels that are adjacent to existing easements or preserves. As of March 25, 2014, 465 of these parcels existed in the watershed (hereafter, “adjacent parcels”). There are 10,728.06 acres of federal priority wetlands within the watershed, and 14,682.92 acres of increasing wetlands or wetlands with no trend assessment (Figure 4). Not surprisingly, all eelgrass beds are in the water and thus barely overlap with any of the property parcels (Figure 5). However, the map is relevant because it reveals which properties are closest to these important ecological features. Symbolizing property parcels by size (Figure 6) revealed that numerous large parcels, over 100 acres in size have not yet been protected in the watershed. Several of these parcels are adjacent to one another. This map (Figure 6) also highlighted that the majority of waterfront parcels are less than or equal to 25 acres in size. Since many of the species included in the Gulf of Maine Watershed Habitat Analysis were fish and shorebirds (see Appendix B), it is logical that parcels adjacent to the Bagaduce River offer the most valuable habitat for these species (Figure 7). However, a number of other parcels offer habitat for large number of species included in the analysis, as shown on the map (Figure 7) in yellow, orange, and red.

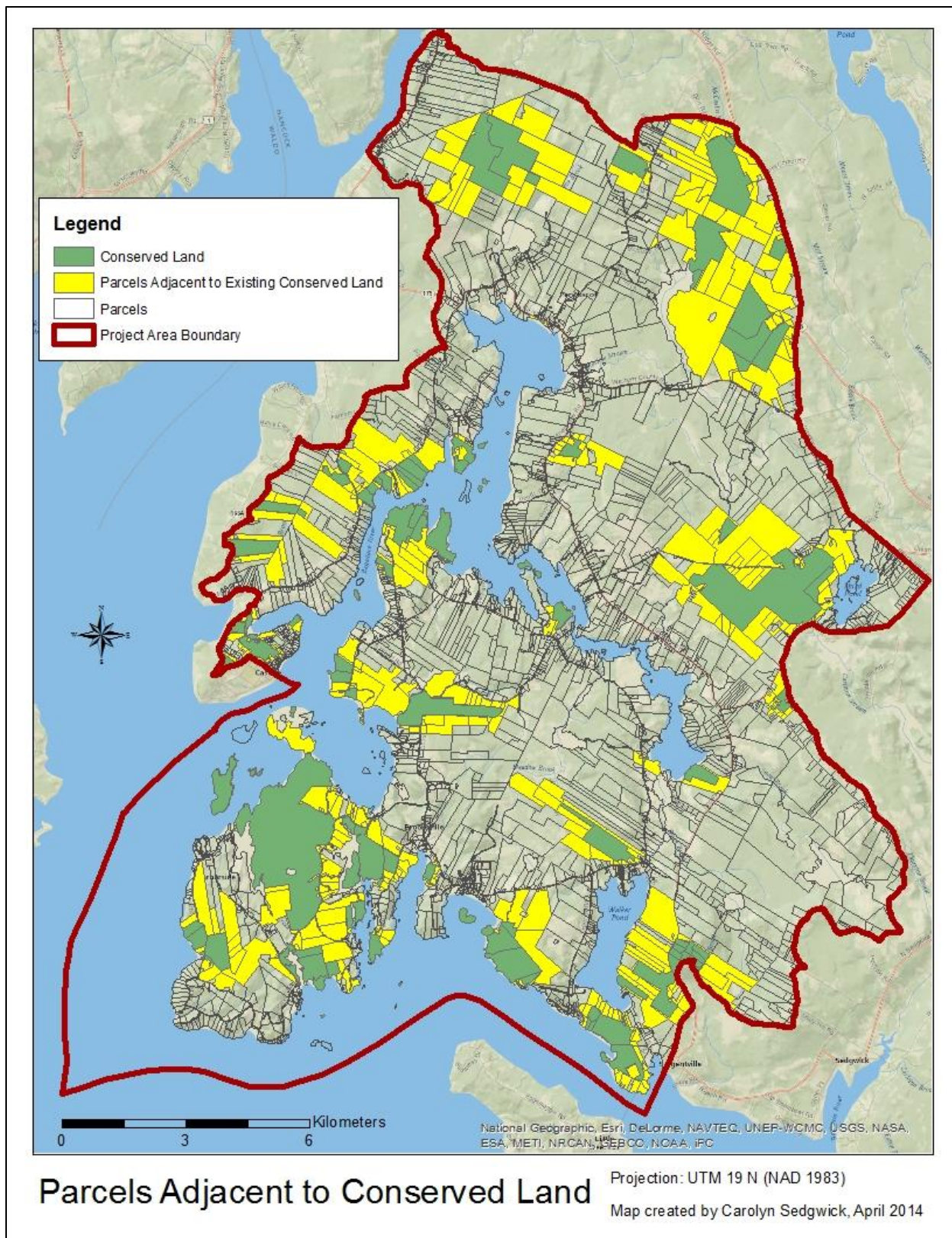


Figure 3. Parcels Adjacent to Existing Conserved Land



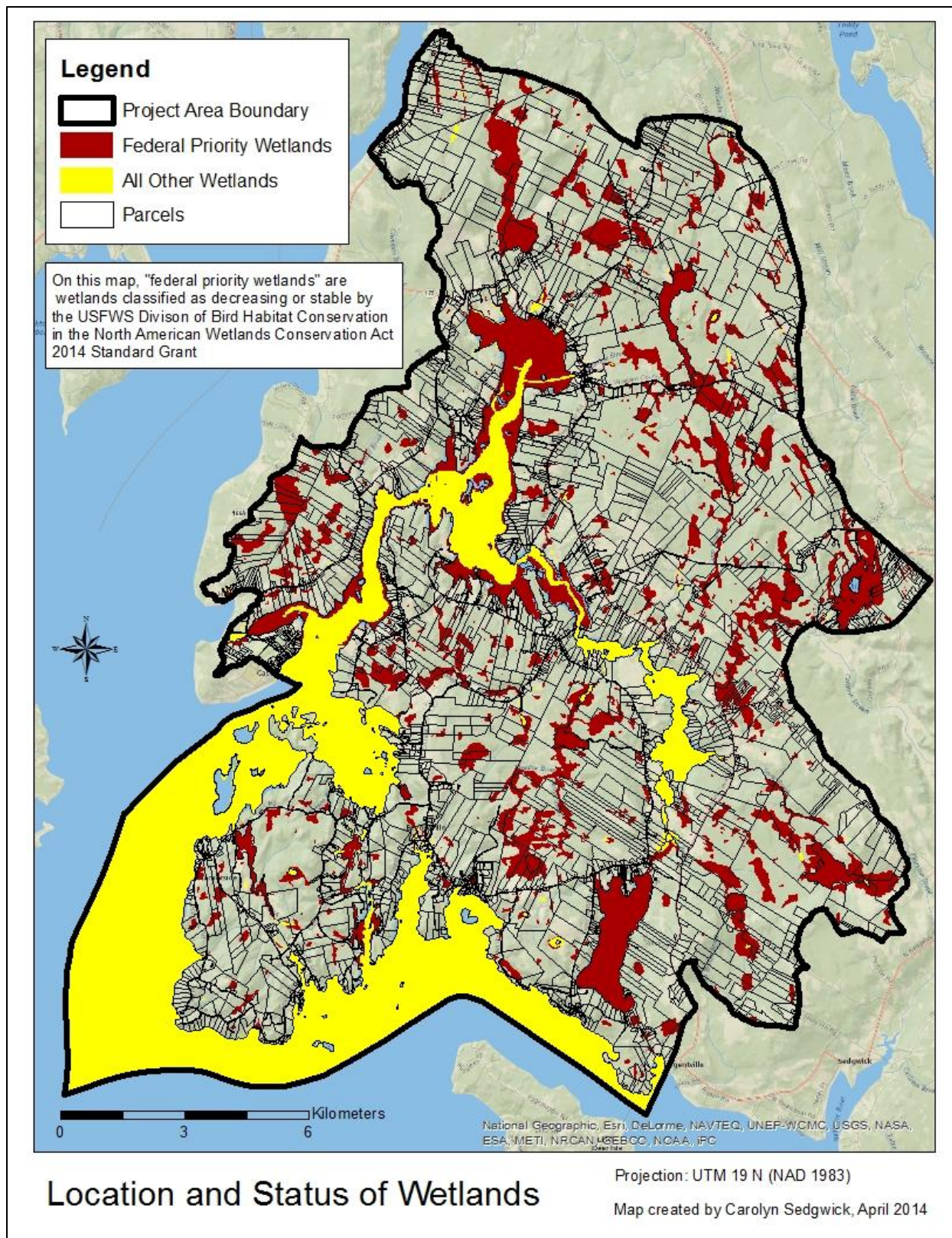


Figure 4. Location and Status of Wetlands



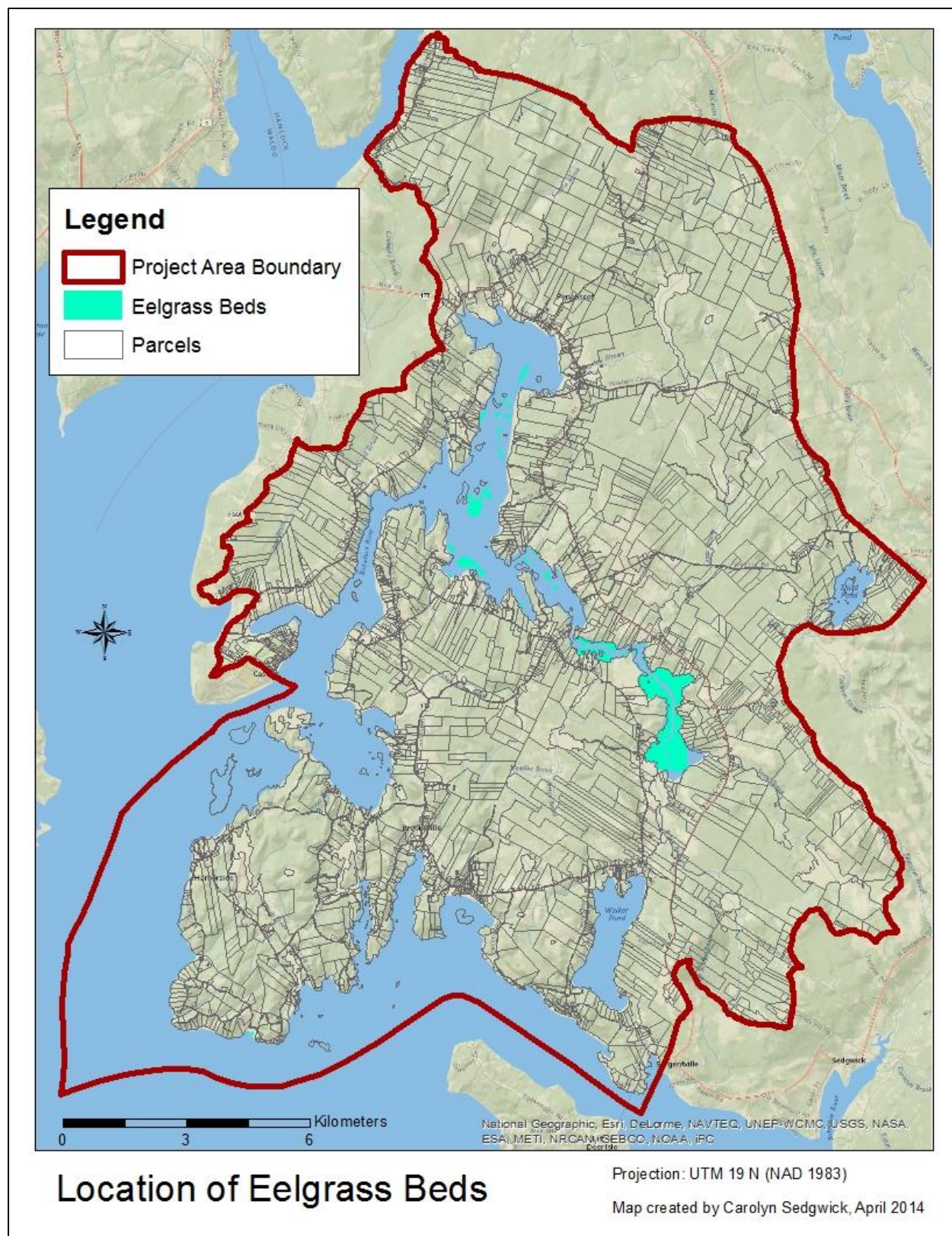


Figure 5. Location of Eelgrass Beds



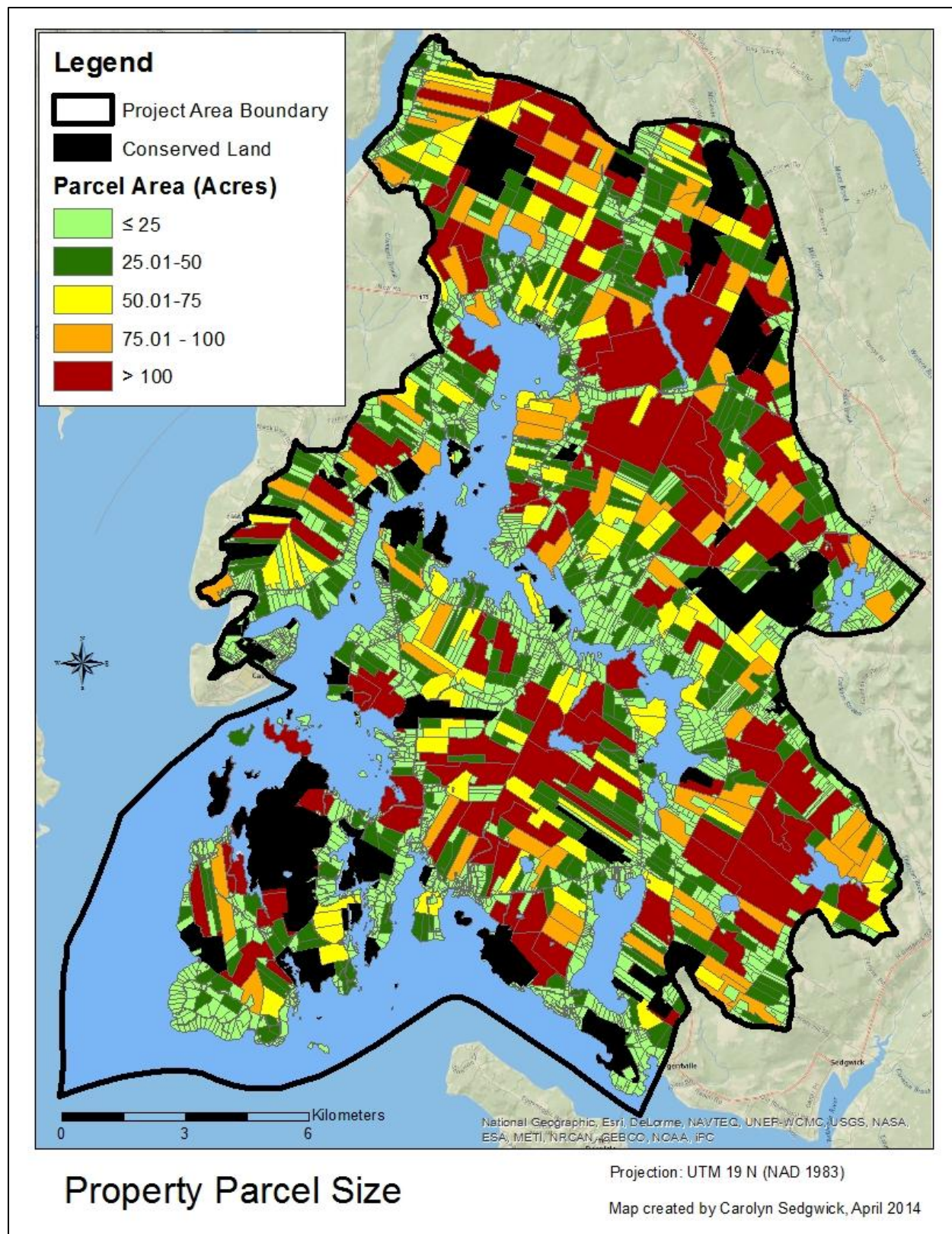


Figure 6. Parcel Size



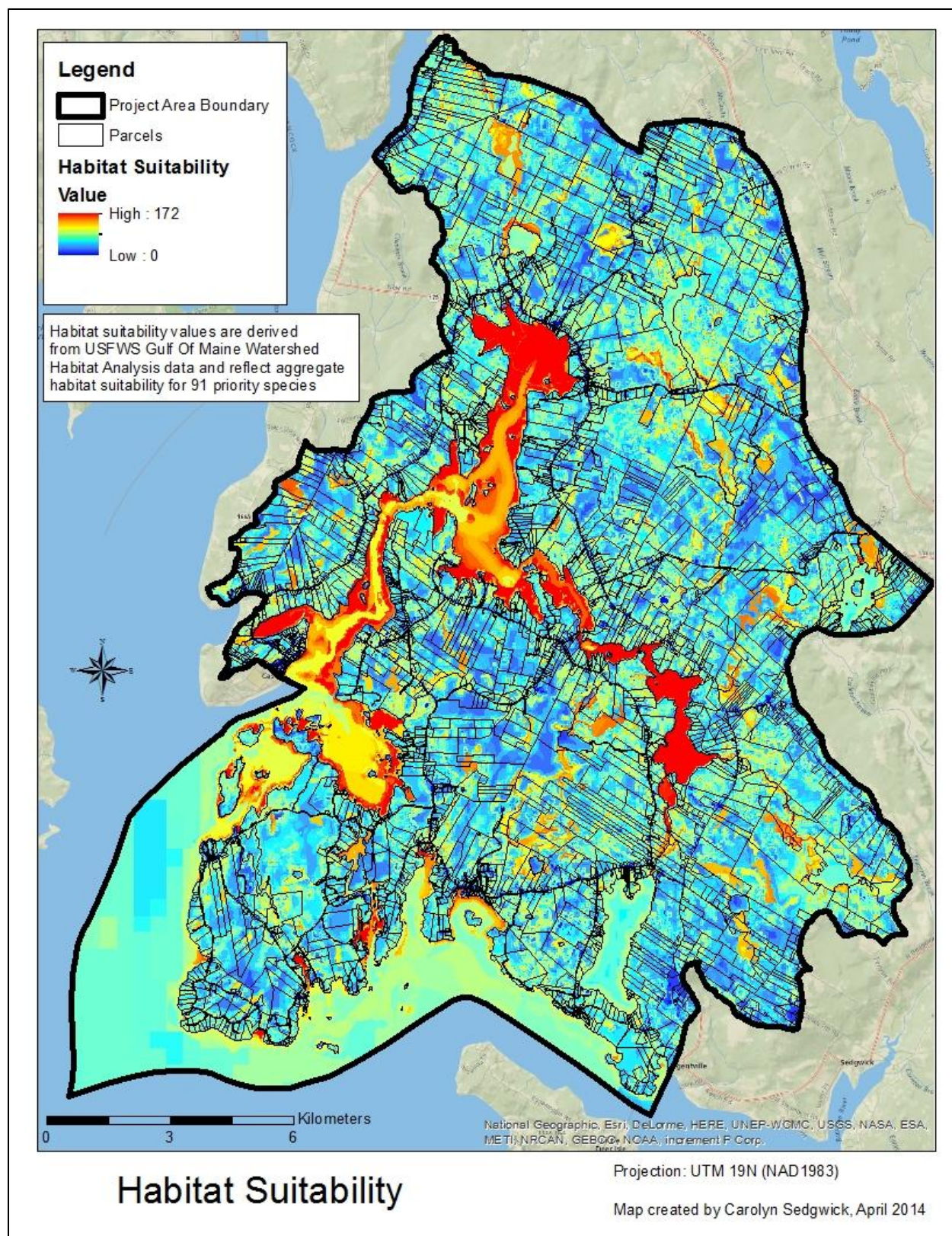


Figure 7. Habitat Suitability

In addition to these maps of individual indicators, I also incorporated multiple ecological indicators into the same map (Figures 8-11). Included here are the four examples that seemed most relevant for MCHT and BHHT's decision making process, given their current priorities. The first multi-criteria map shows the size of parcels that are adjacent to existing protected areas (Figure 8). Overlaying eelgrass beds with the wetland data revealed the status of the wetland associated with each eelgrass bed (Figure 9). All of the eelgrass beds are in wetland areas that are considered to be increasing wetlands, or wetlands for which no data on trends exists. Figure 10 indicates the average habitat suitability value for each of the parcels that is adjacent to an existing protected area. Examining an overlay of wetland extent and status, the size of parcels, and the parcels adjacent to conserved land is perhaps most informative (Figure 11). There are over 450 acres of federal priority wetlands on properties that are adjacent to existing conserved land and over 100 acres in size (Figure 12). These 450 wetlands acres are distributed across 42 different properties in the watershed. The priority wetland acreage on parcels ranged from less than an acre to approximately 60 acres (Figure 13).



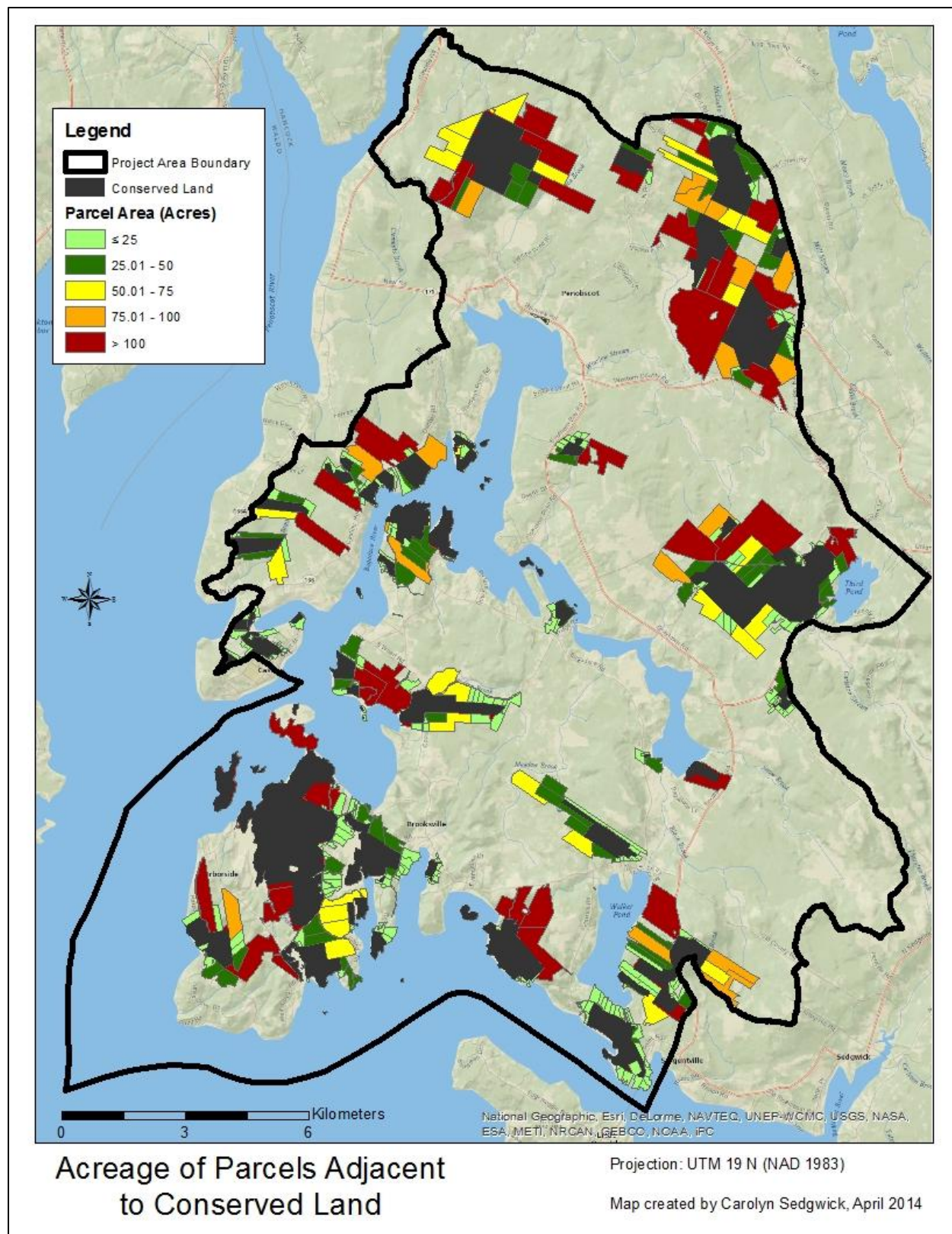


Figure 8. Acreage of Parcels Adjacent to Conserved Land



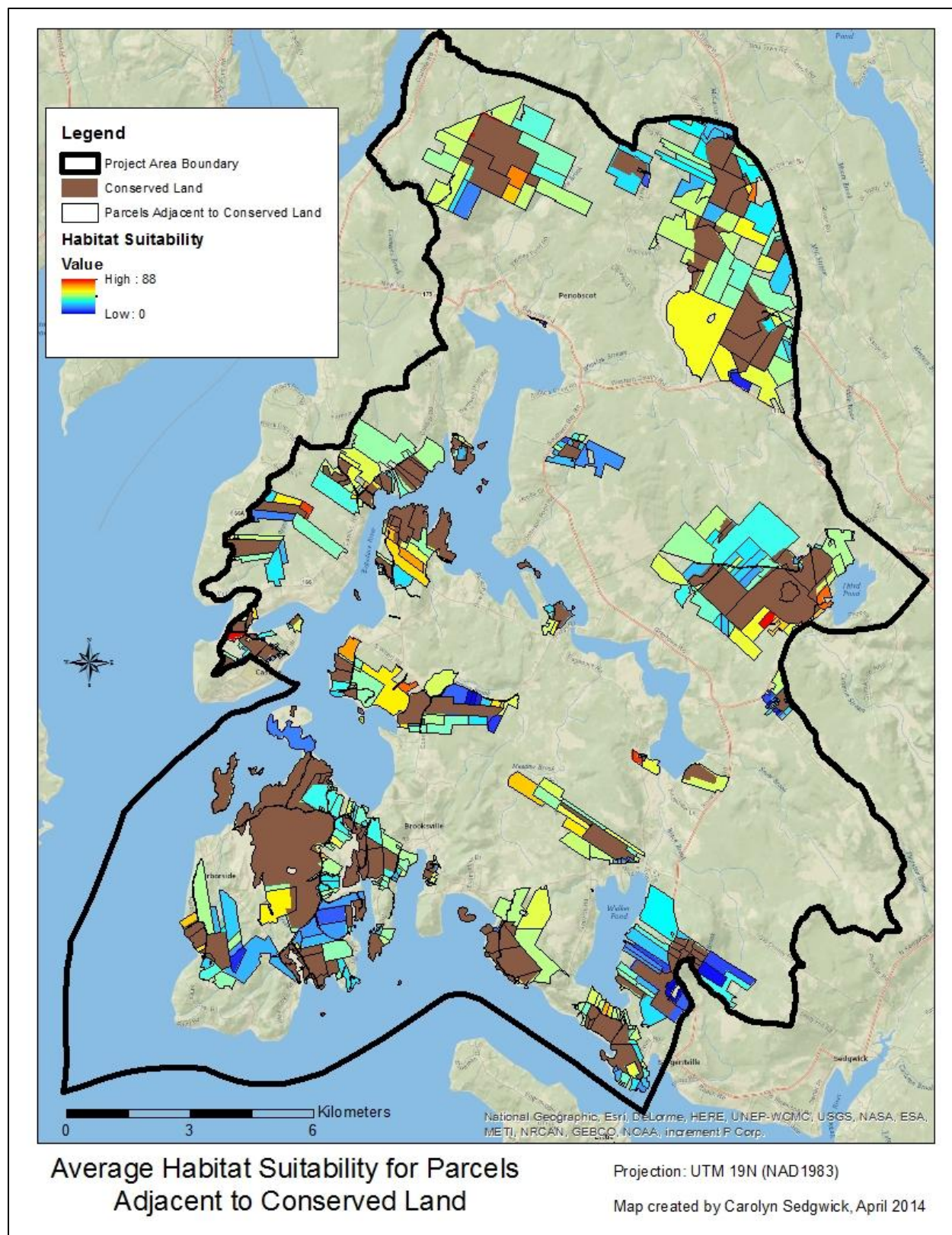


Figure 9. Average Habitat Suitability for Parcels Adjacent to Conserved Land



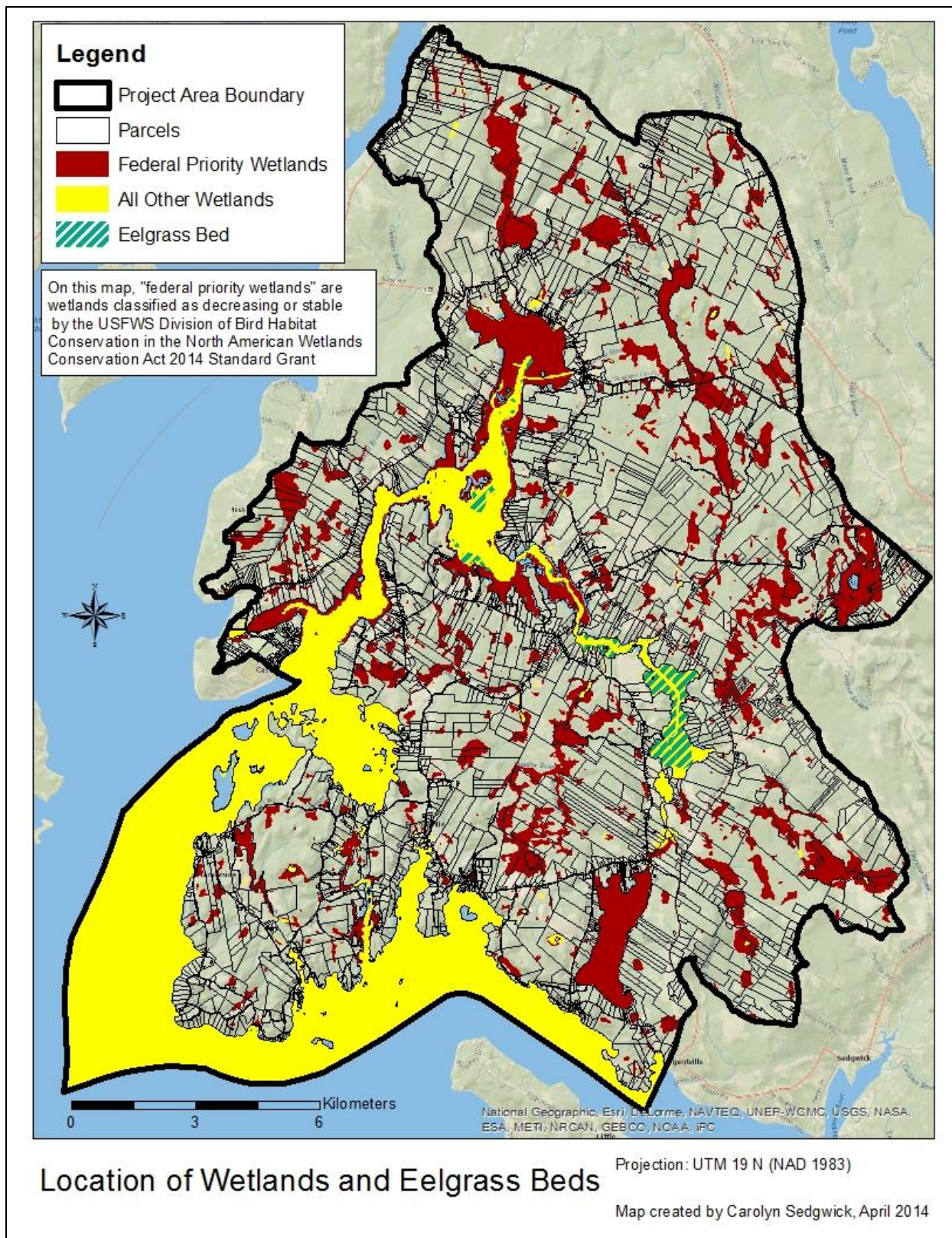


Figure 10. Location of Wetlands and Eelgrass Beds



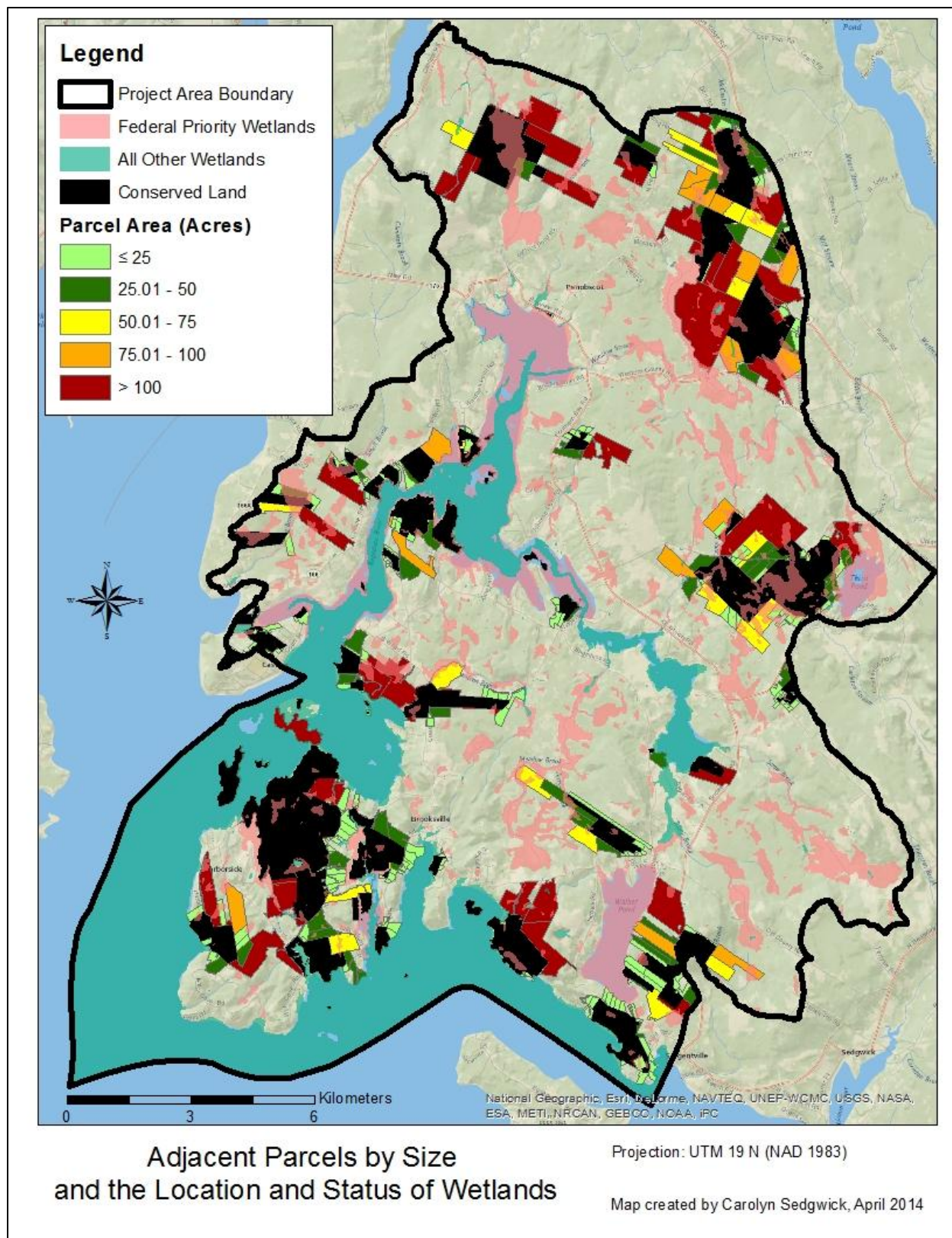


Figure 11. Adjacent Parcels by Size and the Location and Status of Wetlands



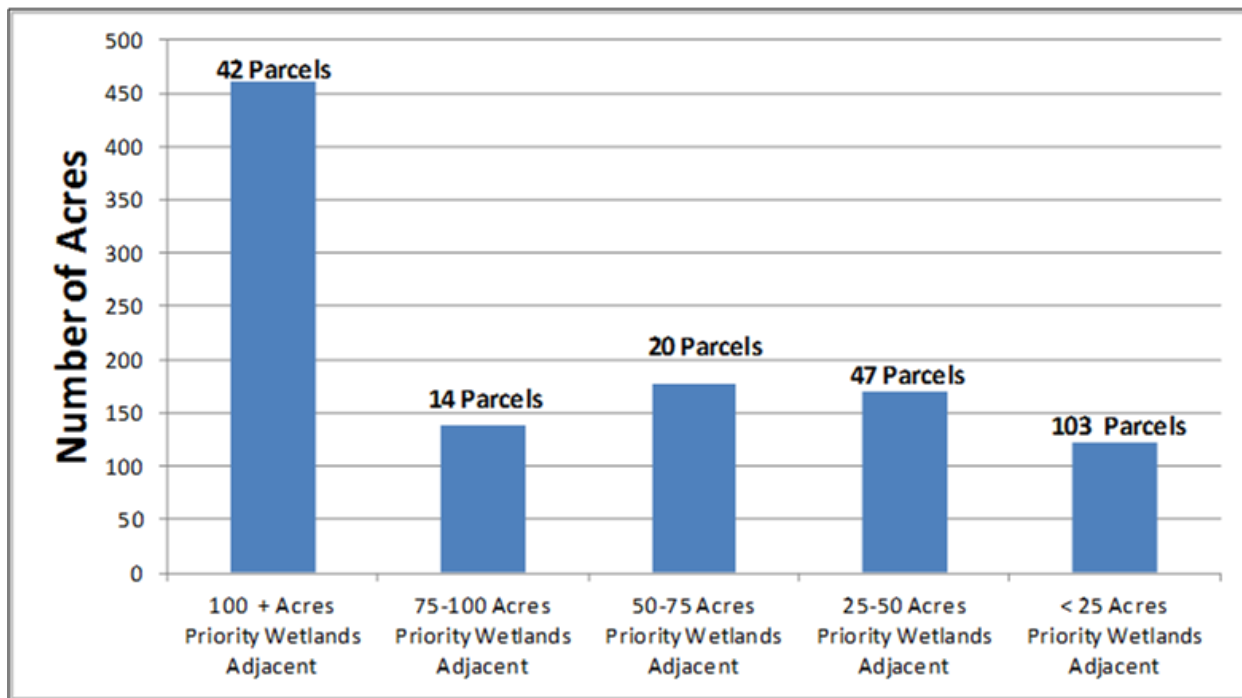


Figure 12. Priority Wetland Acreage on Adjacent Parcels of Different Sizes

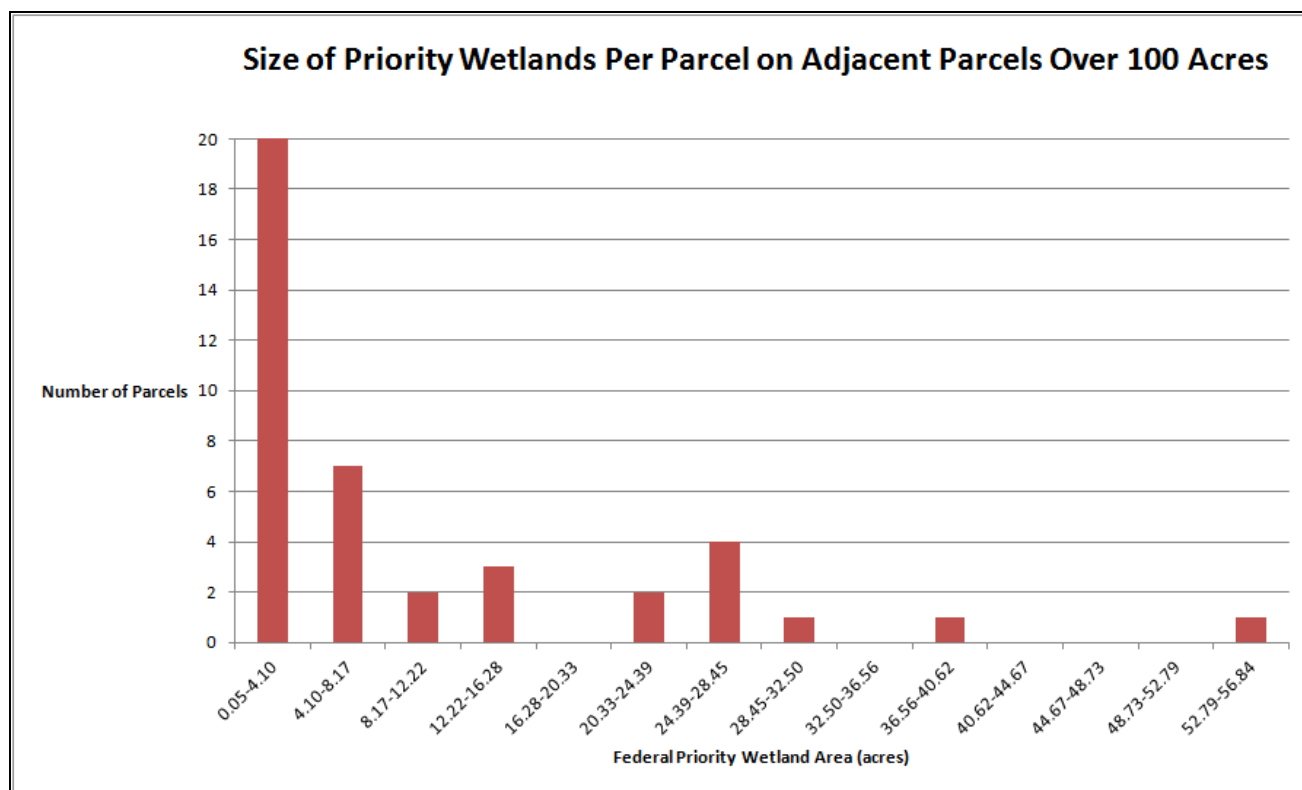


Figure 13. Size of Priority Wetlands Per Parcel on Adjacent Parcels Over 100 Acres

## Discussion

The decision framework and maps produced as part of this master's project are meant to aid MCHT and BHHT in deciding which parcels offer the most conservation benefit in the Bagaduce River watershed. The objectives hierarchy and figures provide a more formal basis for evaluating the ecological benefits of protecting a given land parcel and help identify priority parcels in the watershed. The fact that over 450 acres of priority wetlands exist on properties that are over 100 acres in size and that are adjacent to conserved land suggests that MCHT and BHHT may want to devote more energy to conserving those large priority parcels, instead of initiating land deals on smaller parcels with the same characteristics (Figure 12).

It is important to note that the boundaries of the tax parcel data used in these analyses are approximate and should not be used for survey purposes. Since there was some discrepancy in the boundary lines of the tax parcel dataset and the conserved lands dataset, there may be what look to be extremely small adjacent parcels next to conserved lands. Without seeing a property survey it was unclear whether these small parcels were under separate ownership or whether they should actually be associated with a nearby parcel. Consequently, the quantitative results of the geospatial analyses are also approximate.

While five indicators were chosen for this decision framework, numerous others could also have been incorporated. Any number of other indicators or different data could be used in the future, using the methods presented in this master's project. If the data exists for Hancock County, it might be useful to also incorporate the development status of parcels in the future. It is also important to note that this analysis focused only on assessing the ecological merit at the parcel scale. MCHT and BHHT could reproduce the methods used in this master's project in order to identify areas of highest cultural, scenic, or recreational benefit.

Prioritization and decision making are iterative processes (Gregory et al. 2012; The Nature Conservancy 2003): the identification of optimal properties may depend on previous parcel selections. This is especially pertinent when assessing ecological connectivity. For example, the data for the connectivity indicator used in this analysis—adjacency to existing protected area— changes each time a new property is protected in the watershed. The geospatial models used in these analyses are designed to allow MCHT and BHHT to re-run any of these analyses when new or updated data becomes available.

As with most data, the data used in this analysis were not without limitations. Specifically, one of the datasets used as a measure of habitat quality—the Gulf of Maine Watershed Habitat Analysis—is now 13 years old. It is also heavily focused on fish and birds. The Gulf of Maine Watershed Habitat Analysis is also based off of both species presence data and habitat distribution models. As with any species distribution model, there is some uncertainty regarding how well the model predicts species presence. Despite these potential drawbacks, the Gulf of Maine Watershed Habitat Analysis is the best comprehensive dataset available for species in the Bagaduce region that we were aware of at the time of this project. It would be beneficial if the USFWS were to update their habitat analysis and it would also be valuable to represent more species. Ultimately, board and staff members must determine which parcels would be most beneficial for MCHT and BHHT to focus on, based on local knowledge, landowner relationships, and factors that might not necessarily be portrayed in geospatial figures. However, when complemented with local knowledge, these maps can be invaluable for identifying properties of high conservation value, including those that may have been historically overlooked.

In reality, land conservation is opportunistic. The highest priority parcels may in fact be owned by individuals who are not currently interested in donating or selling their property for conservation purposes. That said, prioritization still helps identify who those landowners are and assists land trusts in determining where outreach is most needed.

## **Conclusions**

Strategic conservation planning facilitates decision making, especially for land trusts like MCHT and BHHT with broad conservation missions. Although the planning process is time intensive, it results in the better and more systematic use of limited resources and thus significantly augments conservation outcomes over time. Organizationally, planning and structured decision making is of enormous benefit to land trusts because it helps them articulate what exactly it is they are trying to protect in the long term. The geospatial analyses I conducted complement the decision framework we derived since they both visually and quantitatively demonstrate which types of properties and critical resources exist in the Bagaduce River watershed, how scarce they are, and how they are interrelated spatially. This strategic conservation plan will permit MCHT and BHHT to be more deliberate in their efforts in the Bagaduce, and will provide a foundation for future conservation action in the region.

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## Appendix

### A. 91 Species Used in USFWS Gulf Of Maine Watershed Habitat Analysis

Alewife	Marsh Wren
American Bittern	Nelson's Sharp-tailed Sparrow
American Black Duck	Northern Flicker
American Eel	Northern Goshawk
American Oystercatcher	Northern Harrier
American Shad	Olive-sided Flycatcher
American Woodcock	Osprey
Arctic Tern	Peregrine Falcon, eastern
Atlantic Salmon	Pied-billed Grebe
Atlantic Sturgeon	Piping Plover
Bald Eagle	Plymouth Redbelly Turtle
Baltimore Oriole	Prairie Warbler
Bay-breasted Warbler	Purple Sandpiper
Bicknell's Thrush	Razorbill
Black Scoter	Red Crossbill
Black Tern	Red Knot
Black-bellied Plover	Red-headed Woodpecker
Blackburnian Warbler	Red-Shouldered Hawk
Blackpoll Warbler	Robbins' Cinquefoil
Black-throated Blue Warbler	Roseate Tern
Blueback Herring	Ruddy Turnstone
Bluefish	Saltmarsh Sharp-tailed Sparrow
Blue-winged Warbler	Sanderling
Buff-breasted Sandpiper	Seaside Sparrow
Canada Lynx	Sedge Wren
Canada Warbler	Semi-palmated Sandpiper
Cape May Warbler	Short-billed Dowitcher
Chestnut-sided Warbler	Short-eared Owl
Common Loon	Shortnose Sturgeon
Common Snipe	Small Whorled Pogonia
Common Tern	Snowy Egret
Eastern Meadowlark	Solitary Sandpiper
Eastern Prairie Fringed Orchid	Spruce Grouse
Field Sparrow	Surf Scoter
Furbish's Lousewort	Tricolored Heron
Golden-winged Warbler	Upland Sandpiper
Grasshopper Sparrow	Veery
Greater Scaup	Whimbrel
Horseshoe Crab	Whip-poor-will
Hudsonian Godwit	White-winged Scoter
Killdeer	Winter Flounder
Least Sandpiper	Wood Duck
Least Tern	Wood Thrush
Lesser Scaup	Yellow Rail
Little Blue Heron	
Little Gull	
Louisiana Waterthrush	

## B. Step-by Step GIS Analyses

### Model 1: Trim Eelgrass Beds, Conserved Lands, and Gulf of Maine Watershed Habitat Analysis Data to Project Area Boundary

Step 1: Trim the aggregated habitat suitability scores from the USFWS Gulf of Maine Watershed Habitat Analysis data to the extent of the Bagaduce River watershed boundary using **Extract by Mask** tool.

Step 2: Clip eelgrass bed shapefile to the extent of the Bagaduce River watershed boundary shapefile using the **Clip** tool.

Step 3: Clip conserved lands shapefile to the extent of the Bagaduce River watershed boundary shapefile using the **Clip** tool.

### Model 2: Parcel Data Preparation

Step 1: Use the **Merge** tool to combine tax parcel shapefiles for Blue Hill, Brooksville, Castine, Orland, Penobscot, and Sedgwick (the 6 towns with parcels in the Bagaduce River watershed project area) into one shapefile.

Step 2: Clip merged parcel shapefile to the extent of the Bagaduce River watershed boundary shapefile using the **Clip** tool.

### Model 3: Wetland Data Preparation

Step 1: Use **Project** tool to change the National Wetland Inventory data to the same projection as all other data in the analysis: UTM Zone 19 N (NAD 1983)

Step 2: Clip the resulting shapefile to the extent of the Bagaduce River watershed boundary shapefile using the **Clip** tool.

### Model 4: Adjacency Analysis

Step 1: Use the **Make Feature Layer** tool to create a feature layer of the parcel data.

Step 2: Use the **Select Layer by Location** tool to select parcels within 10 meters of the conserved lands layer.



\*Note I used “within a distance of” instead of “boundary touching” because of minor errors in the boundaries of the conserved lands parcels and/or the tax parcels. Due to drawing inconsistencies the boundaries didn’t always exactly meet where they theoretically should.

Step 3: Use **Copy Features** tool to make the selection a permanent new shapefile.

Step 4: Use **Erase** tool to remove lands that have already been conserved.

\* Note, because of the way the tax parcels and/or the conserved land parcels were drawn, the adjacency result sometimes depicted very small polygons next to conserved lands. Without seeing an actual survey, it is unknown if those little pieces should actually be associated with either the conserved land or a different tax parcel *or* if they really are extremely small property parcels. For the sake of my analysis, I treated them as small separate parcels.

#### Model 5: Calculate acreage of parcels

Step 1: Add a field to the parcel attribute table using **Add Field** tool. Name it “Area.”

Step 2: Open the attribute table. Right click on the new Area field and select “Calculate Geometry.”

Step 3: Add a field to the adjacent parcel attribute table using **Add Field** tool. Name it “Area.”

Step 4: Open the attribute table. Right click on the new Area field and select “Calculate Geometry.”

#### Model 6: Wetland Coding

Step 1: Use **Select** tool to select all wetlands classified as decreasing (USFWS BHC 2014, p. 16). Query expression= "ATTRIBUTE" LIKE 'PEM%' OR "ATTRIBUTE" LIKE 'PFO%' OR "ATTRIBUTE" LIKE 'PSS%' OR "ATTRIBUTE" LIKE 'E2VEG%'

\*Using the % tags all subclasses of that type.

Step 2: Use **Select** tool to select all wetlands classified as stable (USFWS BHC 2014, p. 16). Query expression= "ATTRIBUTE" LIKE 'E2AB%' OR "ATTRIBUTE" LIKE 'E2US%' OR "ATTRIBUTE" LIKE 'L%' OR "ATTRIBUTE" LIKE 'R%'

Step 3: Use **Select** tool to select all wetlands classified as increasing (USFWS BHC 2014, p. 16). Query expression="ATTRIBUTE" LIKE 'M2%' OR "ATTRIBUTE" LIKE 'PAB%' OR "ATTRIBUTE" LIKE 'PUB%' OR "ATTRIBUTE" LIKE 'POW%' OR "ATTRIBUTE" LIKE 'PUS%'

Step 4: Use **Select** tool to select all wetlands classified as having no trend assessment (USFWS BHC 2014, p. 16). Query expression= "ATTRIBUTE" LIKE 'E1%' OR "ATTRIBUTE" LIKE 'PML%' OR "ATTRIBUTE" LIKE 'PRB%'

Step 5: Use **Select** tool to select the remaining wetland types that fell into none of these 4 categories (USFWS BHC 2014, p. 16). Query expression= "ATTRIBUTE" LIKE 'M1%' OR "ATTRIBUTE" LIKE 'E2EM%'.

Step 6: Use **Merge** tool to combine the decreasing and stable wetland shapefiles and name them “Federal Priority Wetlands.”

\*The North American Wetlands Conservation Act 2014 standard grant (USFWS BHC 2014, p. 16) prioritizes decreasing and stable wetlands over increasing wetlands or wetlands with no data trend available.

Step 7: Use **Merge** tool to combine the increasing wetlands, wetlands lacking a trend assessment, and unclassified wetlands and name them “All Other Wetlands.”

Step 8: Add a field to the “Federal Priority Wetland” attribute table using **Add Field** tool. Name it “Wetland Area.”

Step 9: Open the attribute table. Right click on the new Wetland Area field and select “Calculate Geometry.”

Step 10: Add a field to the “All Other Wetlands” attribute table using **Add Field** tool. Name it “Wetland Area.”

Step 11: Open the attribute table. Right click on the new Wetland Area field and select “Calculate Geometry.”

#### Model 7: Average Habitat Suitability in Adjacent Parcels

Step 1: Use **Zonal Statistics** tool and use the adjacent parcels as the features zones and the habitat suitability raster as the input value raster. Select “Mean” as Statistic Type.

#### Model 8: Calculate Priority Wetland Acreage on Adjacent Parcel of Different Size Classes

Step 1: Use **Intersect** tool to make a shapefile of the region where federal priority wetlands overlap with adjacent parcels.

Step 2: Using the result from Step 1, use the **Select** tool to select adjacent parcels that are over 100 acres (out of the ones that have priority wetlands). Use the area attribute field calculated in Model 5, Step 4. Query expression= "Area\_Acres" > 100

Step 3: Using the result from Step 1, use the **Select** tool to select adjacent parcels that are over 75 acres but less than 100 acres. Use the area attribute calculated in Model 5 Step 4. Query expression= "Area\_Acres" > 75 AND "Area\_Acres" <= 100

Step 4: Using the result from Step 1, use the **Select** tool to select adjacent parcels that are over 50 acres but less than 75 acres. Use the area attribute calculated in Model 5 Step 4. Query expression= "Area\_Acres" > 50 AND "Area\_Acres" <= 75

Step 5: Using the result from Step 1, use the **Select** tool to select adjacent parcels that are over 25 acres but less than 50 acres. Use the area attribute calculated in Model 5 Step 4. Query expression= "Area\_Acres" > 25 AND "Area\_Acres" <= 50

Step 6: Using the result from Step 1, use the **Select** tool to select adjacent parcels that are at least 25 acres. Use the area attribute calculated in Model 5 Step 4. Query expression= "Area\_Acres" <= 25

Steps 7-11: Use the **Summary Statistics** tool to determine the total priority wetland acreage per adjacent parcel for each of the size classes using the results calculated in Steps 2-6. Use the wetland acreage attribute field (calculated in Model 6, Step 9) in the result from the previous step as the Statistic Field. Choose "Sum" as the statistic type. In the case field choose the ID of the adjacent parcels.

Steps 8-12: Use **Join Field** tool to join the attribute tables from steps 7-11 to each of their respective tables from steps 2-6 using the ID of adjacent parcels as the Join Field.